AG-210
THE QUATERNARY HISTORY OF SVALBARD

11 August – 9 December 2011

Deadline for application: 15 April 2011
More information: http://www.unis.no/studies
Pictures of the cruise and excursion 2010:

http://www.unis.no/35_STAFF/staff_webpages/geology/anne_hormes/web/AG-210_in_2010.html

Please, find more information below that is subject to last minute changes.

Students working in sediment sections in Linnédalen

General information
The course is taught at the University Centre in Svalbard (UNIS, http://www.unis.no) situated in Longyearbyen in the High Arctic with flight connections from Tromsø and Oslo, Norway (http://www.sas-braathens.no). Housing is offered by the student housing organisation. The rooms are of basic good standard with common bathrooms and kitchen for 4-6 rooms. One month rent is approximately 3400.- NOK.

Please contact anne.bjorndal@unis.no for course registration and sito@unis.no for booking of student housing rooms.

Participants should bring warm and watertight clothing and backpack coverage. In average, temperature is around 5ºC in August and 0ºC in September. Snowfall is possible in both months. **The cruise will be accomplished 22-25 August**. **The obligatory tent camp is planned for 25-29 August.** Don't forget to bring your camera and field logbook.

Tent camp at Rudmosepynten, Billefjorden

Course details
Credits: 15 ETCS
Duration: one semester (autumn 2011)
Teaching: 45 hours of lectures, 25 hours of seminars/group work with field exercises, 4 days cruise and 4 days tent camp (obligatory)
Exam: 9 December 2011

Evaluation
Graded. Assessed term project (written report and oral presentation): 40%. Written 3 hours exam: 60%. Approved field report.

Responsible for the course
Dr. Anne Hormes, UNIS (anne.hormes@unis.no)

Course teachers
Associate Professor Maria Jensen, UNIS
Professor Al Werner, Mount Holyoke College, Massachusetts, USA
PhD student Endre Før Gjermundsen, UNIS
Professor Ólafur Ingólfsson, University of Iceland / Adjunct Professor at UNIS
Postdoc Carmen Vega, Uppsala University, Sweden

Schedule

The course will begin with the compulsory **safety training on Thursday and Friday 11-12 August, 2011.** Meet in the foyer of UNIS at 08:30. Please plan your arrival in Longyearbyen accordingly, no later than Wednesday the 10 August. Do not travel outside Longyearbyen until you have completed the safety training.

Syllabus

Introduction (AH)
Quaternary Climate Change
Quaternary Stratigraphy
Quaternary Geology of Svalbard – Overview and field sites
Methods in Quaternary Geology
Svalbard Barents sea ice sheet
Introduction to the field sites and aims of field excursion (AH)
Exercise: Term projects

Glaciers on Svalbard and glacial processes (EFG)
Satellite image processing
GIS application in Quaternary Geology

LAB: Satellite image processing, GIS applications in Quaternary Geology
Digital air photograph data processing
DTM application in Quaternary Geology

Quaternary Dating methods – relative methods (Biological methods, Amino-acid racemization, Isochroneity), dendrochronology, varves, radiometric methods (radiocarbon, cosmogenic radionuclide dating) luminescence (AH)
Exercise: Oral presentations of field reports

Holocene records of Svalbard (AW)
Lake sediment records of Svalbard
LAB: Lake sedimentation processes
Sediment description
Sampling and measurement strategies

Quaternary landforms (AH, MJ)
Glacial sediments
LAB: Fabric analysis

Nonglacial sediments and landforms (MJ)
Eustatic sea level rise and glacial isostasy – principles
Sea level history and glacial isostasy on Svalbard
LAB: Exercise with data from Svalbard marine terraces – glacial isostasy

Glaciotectonics and sediments of surge-type glaciers (OI)
Quaternary lithostratigraphy of the key site Poolepynten and the history of polar bears
Quaternary lithostratigraphy of Kongsøya
Quaternary lithostratigraphy of Phippsøya

Ice core records – principles (CV)

Ice core records from Svalbard
LAB: Glacier response on Milankovic cycles

Svalbard-Barents-sea ice sheet – a dynamic concept (AH)
Decay of the Svalbard-Barents-sea ice sheet
Exercise: Field observations and literature
Term project oral presentations

Preliminary Reading list AG-210

Students will find all relevant papers at UNIS. References in bold font might be read in advance as course introduction. Textbooks are available at the UNIS library only in limited numbers. Students should consider purchasing Benn and Evans, 2010.

Books

Benn, D.I., and Evans, D.J.A., 2010, Glaciers and Glaciation. New York, John Wiley and Sons, Inc., **2nd edition**. Pages 3-21, 233-256, 259-282, 294-311, 316-324, 333-390, 395-404, 427-433, 436-441, 442-468, 472-528, 534-548, 568-579, 597-606, 619-621, 636-644, 651-671, 644-647, 671-673

Ruddiman, W. F. 2008. *Earth's climate: Past and Future.* W.H. Freeman & Co Ltd. Pages 116- 135, 155-166, 229-246, 251-269, 289-308, appendixes

Paleoclimate in the Arctic

Miller, G. H., Brigham-Grette, J., Alley, R. B., Anderson, L., Bauch, H. A., Douglas, M. S. V., Edwards, M. E., Elias, S. A., Finney, B. P., Fitzpatrick, J. J., Funder, S. V., Herbert, T. D., Hinzman, L. D., Kaufman, D. S., MacDonald, G. M., Polyak, L., Robock, A., Serrze, M. C., Smol, J. P., Spielhagen, R., White, J. W. C., Wolfe, A. P. & Wolff, E. W. 2010: **Temperature and precipitation history in the Arctic.** *Quaternary Science Reviews*, 29**,** 1679-1715.

Kaufman, D. S., Schneider, D. R., McKay, N. P., Ammann, C. M., Bradley, R. S., Briffa, K. R., Miller, G. H., Otto-Bliesner, B. L., Overpeck, J. T., Vinther, B. M., Abbott, M., Axford, Y., Bird, B., Birks, H. J. B., Bjune, A. E., Briner, J., Cook, T., Chipman, M., Francus, P., Gajewski, K., Geirsdóttir, Á., Hu, F. S., Kutchko, B., Lamoureux, S., Loso, M., MacDonald, G., Peros, M., Porinchu, D., Schiff, C., Seppä, H. & Thomas, E. 2009: **Recent Warming reverses Long-term Arctic cooling**. *Science*, 325**,** 1236-1239.

Field excursion

Ingólfsson, Ó., 2009, Guide to the Quaternary Geology of Western Svalbard, Internal report UNIS, p. 98.

Introduction to the Quaternary Geology of Svalbard

Dowdeswell, J.A., Hogan, K.A., Evans, J., Noormets, R., O Cofaigh, C., Ottesen, D., 2010. Past ice-sheet flow east of Svalbard inferred from streamlined subglacial landforms. Geology 38, 163-166.

Landvik, J.Y., Ingolfsson, O., Mienert, J., Lehman, S.J., Solheim, A., Elverhøi, A., and Ottesen, D., 2005, Rethinking Late Weichselian ice-sheet dynamics in coastal NW Svalbard.: Boreas, v. 34, p. 7-24. – 17 pp.

Mangerud, J., Dokken, T., Hebbeln, D., Heggen, B., Ingólfsson, O., Landvik, J.Y., Mejdahl, V., Svendsen, J.I., and Vorren, T.O., 1998,

Fluctuations of the Svalbard-Barents Sea Ice Sheet during the last 150 000 years.: Quaternary Science Reviews, v. 17, p. 11-22. – 11 pp.

Methods in Quaternary Geology

Evans, D.J.A. and Benn, D.I., 2004. A Practical guide to the study of glacial sediments. Arnold, London, pp. 266.

Forman, S. L. 1999. Infrared and Red Stimulated Luminescence Dating of Late Quaternary near-shore sediments from Spitsbergen, Svalbard. *Arctic, Antarctic, and Alpine Research*, 31**,** 34-49.

Ivy-Ochs, S. & Kober, F. 2008. **Surface exposure dating with cosmogenic nuclides.** *Quaternary Science Journal*, 57**,** 179-209. In: Preusser, F., Hajdas, I. & Ivy-Ochs, S. (Eds.), 2008: Recent progress in Quaternary dating methods. Quaternary Science Journal, Special Issue, pp. 252, Schweizerbart.

Quaternary landforms

Ottesen, D., Dowdeswell, J.A., 2009. An inter-ice-stream glaciated margin: Submarine landforms and a geomorphic model based on marine-geophysical data from Svalbard. Geological Society of America Bulletin. doi: 10.1130/B26467.1

Landvik, J. Y., Brook, E. J., Gualtieri, L., Raisbeck, G., Salvigsen, O. & Yiou, F. 2003. Northwest Svalbard during the last glaciation: Ice-free areas existed. *Geology*, 31**,** 905-908.

Geomorphological and Quaternary geological map of Svalbard 1:100,000 C9G/C9Q Adventdalen. Norwegian Polar Institute, Tromsø, 2001.

Quaternary stratigraphy and relative sea level

Alexanderson, H., Landvik, J. Y. & Ryen, H. T. 2011: Chronology and styles of glaciation in an inter-fjord setting, northwestern Svalbard. *Boreas*, 40**,** 175-197.

Forman, S.L., Lubinski, D.J., Ingolfsson, O., Zeeberg, J.J., Snyder, J.A., Siegert, M.J., and Matishov, G.G., 2004, A review of postglacial emergence on Svalbard, Franz Josef Land and Novaya Zemlya, northern Eurasia.: Quaternary Science Reviews, v. 23, p. 1391-1434. – 43 pp.

Ingólfsson, O., Rögnvaldsson, F., Bergsten, H., Hedenäs, L., Lemdahl, G., Lirio, J.M., and Sejrup, H.P., 1995, Late Quaternary glacial and environmental history of Kongsøya, Svalbard. Polar Research, v. 14, p. 123-139. – 16 pp.

Holocene

Kaufman, D. S., Ager, T. A., Anderson, N. J., Anderson, P. M., Andrews, J. T., Bartlein, P. J., Brubaker, L. B., Coats, L. L., Cwynar, L. C., Duvall, M. L., Dyke, A. S., Edwards, M. E., Eisner, W. R., Gajewski, K., Geirsdóttir, Á., Hu, F. S., Jennings, A. E., Kaplan, M. R., Kerwin, M. W., Lozhkin, A. V., MacDonald, G. M., Miller, G. H., Mock, C. J., Oswald, W. W., Otto-Bliesner, B. L., Porinchu, D. F., Rühland, K., Smol, J. P., Steig, E. J. & Wolfe, B. B. 2004: Holocene thermal maximum in the western Arctic (0-180°W). *Quaternary Science Reviews*, 23**,** 529-560.

Humlum, O., Elberling, B., Hormes, A., Fjordheim, K., Hansen, O.H., and Heinemeier, J., 2005, Late-Holocene glacier growth on Svalbard, documented by subglacial relict vegetation and living soil microbes. The Holocene, v. 15, p. 419-430. – 11 pp.

Svendsen, J.I., and Mangerud, J., 1997, Holocene glacial and climatic variations on Spitsbergen, Svalbard. The Holocene, v. 7, 1, p. 45-57. – 12 pp.

Velle, G., Kongshavn, K. & Birks, H. J. B. 2011: Minimizing the edge-effect in environmental reconstructions by trimming the calibration set: Chironomid-inferred temperatures from Spitsbergen. *The Holocene*, 21**,** 417-430.

Additional reading

Methods

Krüger, J., and Kjær, K.H., 1999, A data chart for field description and genetic interpretation of glacial diamicts and associated sediments - with examples from Greenland, Iceland and Denmark. Boreas, v. 28, p. 386-402. – 16 pp.

Krüger, J., and Kjær, K.H., 2005, Fabric pattern in a basal till succession and its significance for reconstructing subglacial processes - discussion. Journal of Sedimentary Research, v. 75, p. 323-326. – 3 pp.

Quaternary Dating Methods

Briner, J.P., Miller, G.H., Thompson Davis, P. and Finkel, R.C., 2006. Cosmogenic radionuclides from fiord landscapes support differential erosion by overriding ice sheets. GSA Bulletin, 118(3/4), 406-420.

Glacial history of the Svalbard – Barents - Kara Sea region

Ingólfsson, Ó., Möller, P. and Lokrantz, H., 2008. Late Quaternary marine-based Kara Sea ice sheets: a review of terrestrial stratigraphic data highlighting their formation. Polar Research, 27, 152-161.

Siegert, M.J., Dowdeswell, J.A., Svendsen, J.I., and Elverhøi, A., 2002, The Eurasian Arctic during the last Ice Age. American Scientist, v. 90, p. 32-39.

Spielhagen, R.F., Baumann, K.H., Erlenkeuser, H., Nowaczyk, N.R., Nørgaard-Pedersen, N., Vogt, C., and Weiel, D., 2004, Arctic Ocean deep-sea record of northern Eurasian ice sheet history.: Quaternary Science Reviews, v. 23, p. 1455-1483.

Svendsen, J.I., Alexanderson, H., Astakhov, V.I., Demidov, I., Dowdeswell, J.A., Funder, S., Gataullin, V., Henriksen, M., Hjort, C., and Houmark-Nielsen, M., 2004, Late Quaternary ice sheet history of northern Eurasia. Quaternary Science Reviews, v. 23, p. 1229-1271. – 42 pp.

Glacial processes and surging glaciers

Kristensen, L., Benn, D.I., Hormes, A., Ottesen, D., 2009. Mud aprons in front of Svalbard surge moraines: Evidence of subglacial deforming layers or proglacial glaciotectonics? Geomorphology 111, 206-221.

Sund, M., Eiken, T., Hagen, J.O. and Kääb, A., 2009. Svalbard surge dynamics derived from geometric changes. Annals of Glaciology, 50(52), 50-60.

Quaternary landforms and sediments

Kjær, K.H., Larsen, E., van der Meer, J., Ingolfsson, O., Krüger, J., Bendiktsson, I., Knudsen, C.G., and Schomacker, A., 2006, Subglacial decoupling at the sediment/bedrock interface: a new mechanism for rapid flowing ice. Quaternary Science Reviews, v. 25, p. 2704-2712.

Lukas, S., Nicholson, L.I., Ross, F.H., and Humlum, O., 2005, Formation, meltout processes and landscape alteration of high-arctic ice-cored moraines - examples from Nordenskiöldland, central Spitsbergen. Polar Geography, v. 29, p. 157-187. – 30 pp.

Quaternary stratigraphy and relative sea level

Andersson, T., Forman, S.L., Ingólfsson, O., and Manley, W., 1999, Late Quaternary environmental history of central Prins Karls Forland, Svalbard. Boreas, v. 28, p. 292-307. – 17 pp.

Bondevik, S., Mangerud, J., Ronnert, L. and Salvigsen, O., 1995. Postglacial sea-level history of Edgeøya and Barentsøya, eastern Svalbard. Polar Research, 14, 153–180.

Ingólfsson, O., Wiig, Ø., 2008. Late Pleistocene fossil find in Svalbard: the oldest remains of a polar bear (Ursus maritimus Phipps, 1744) ever discovered. Polar research 2008, 455-462.

Interglacials and Interstadials

Houmark-Nielsen, M., and Funder, S., 1999, Pleistocene stratigraphy of Kongsfjordhallet, Spitsbergen, Svalbard.: Polar Research, v. 18, p. 39-49.

Holocene records on Svalbard

Hald, M., Dahlgren, T., Olsen, T.-E., Lebesbye, E:, 2001. Late Holocene palaeoceanography in Van Mijenfjorden, Svalbard. Polar Research, 20(1), 23-35.

Holmgren, S.U., Bigler, C., Ingolfsson, O. and Wolfe, A.P., 2009. The Holocene-Anthropocene transition in lakes of western Spitsbergen, Svalbard (Norwegian High Arctic): climate change and nitrogen deposition. Journal of Paleolimnology.

Isaksson, E., Hermanson, M., Hicks, S., Igarashi, M., Kamiyama, K., Moore, J., Motoyama, H., Muir, D., Pohjola, V.A., Vaikmäe, R., van de Wal, R.S.W., and Watanabe, O., 2003, Ice cores from Svalbard - useful archives of past climate and pollution history. Physics and Chemistry of the Earth, v. 28, p. 1217-1228. – 11pp.

Isaksson, E., Kohler, J., Moore, J., Pohjola, V., Igarashi, M., Karlöf, L., Martma, T., Meijer, H.A.J., Motoyama, H., and Van de Wal, R.S.W., 2005, Two ice-core $d^{18}O$ records from Svalbard illustrating climate and sea-ice variability over the last 400 years. The Holocene, v. 15, p. 501-509.

Kekonen, T., Moore, J., Perämäki, P., Mulvaney, R., Isaksson, E., Pohjola, V., and Van de Wal, R.S.W., 2005, The 800 year long ion record from the Lomonosovfonna (Svalbard) ice core. Journal of Geophysical Research, v. 110, p. D07304.

Snyder, J.A., Werner, A., and Miller, G.H., 2000, Holocene cirque glacier activity in western Spitsbergen, Svalbard: sediment records from proglacial Linnévatnet. The Holocene, v. 10, p. 555-563. – 8 pp.

Werner, A., 1993, Holocene moraine chronology, Spitsbergen, Svalbard: lichenometric evidence for multiple neoglacial advances in the Arctic. The Holocene, v. 3, p. 128-137. – 9 pp.

Climate in general

Clark, P.U., Dyke, A.S., Shakun, J.D., Carlson, A.E., Clark, J., Wohlfarth, B., Mitrovica, J.X., Hostetler, S.W. and McCabe, A.M., 2009. The Last Glacial Maximum. Science, 325(5941), 710-714.

CCSP, 2009. Past Climate Variability and Change in the Arctic and at High Latitude. A report by the U.S. Climate Change Program and Subcommittee on Global Change Research [Alley, R.B., Brigham-Grette, J., Miller, G.H., Polyak, L., White, J.W.C.]. Reston. http://www.climatescience.gov/Library/sap/sap1-2/final-report/default.htm#finalreport

Wanner, H., Beer, J., Bütikofer, J., Crowley, T.J., Cubasch, U., Flückiger, J., Gosse, J., Grosjean, M., Joos, F., Kaplan, J.O., Küttel, M., Müller, S.A., Prentice, I.C., Solomina, O., Stocker, T.F., Tarasov, P., Wagner, M. and Widmann, M., 2008. **Mid-to Late Holocene climate change: an overview.** Quaternary Science Reviews, 27, 1791-1828.